DOCUMENT RESUME

ED 039 723 56 EM 008 056

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TITLE Cost Effectiveness Evaluation of Instructional Technology: The Problems.
INSTITUTION Academy for Educational Development, Inc., Washington, D.C.
SPONS AGENCY Office of Education (DHEW), Washington, D.C. Bureau of Research.
BUREAU NO BR-8-0571
PUB DATE [70]
NOTE 15p.; This is one of the support papers for "To Improve Learning; a Report to the President and the Congress of the United States by the Commission on Instructional Technology", ED 034 905

EDRS PRICE EDRS Price MF-$0.25 HC-$0.85
DESCRIPTORS *Cost Effectiveness, Educational Planning, *Educational Technology

ABSTRACT

Problems that arise in applying cost effectiveness evaluations to instructional technologies are outlined in this paper, to explain that schools can draw on no available knowledge to determine whether the new instructional strategies will be more effective than traditional instructional approaches, once costs have been taken into account. The paper shows that most of the requirements for sound cost effectiveness analysis cannot be satisfied, given our present knowledge of the educational process. (SP)

COST EFFECTIVENESS EVALUATION OF INSTRUCTIONAL TECHNOLOGY: THE PROBLEMS

by Henry M. Levin*

Introduction

Over the last two decades our society has experienced a revolution in decision-making processes. Where government and business once chose strategies on the basis of very meager information and intuition, modern decision-making relies upon the use of abundant sources of data, sophisticated analytical techniques, and high speed digital computers. Since most enterprises operate with a limited budget, they wish to make decisions that maximize output for any given cost or, conversely, minimize the costs for any given outcome. Such goals have stimulated the development of a set of tools for determining the probable costs and benefits of alternative management strategies. These methods are classified broadly under the term of cost-effectiveness techniques since they are designed to aid in choosing those approaches which yield the best outcome for any given cost._/

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_/ An overview can be found in Thomas A. Goldman (ed.) Cost Effectiveness Analysis: New Approaches in Decision-Making (New York: Frederick A. Praeger, Inc., 1967).

Concurrent with the recent revolution in management science and its particular branch of cost-effectiveness analysis has been the proliferation

of new instructional technologies for the schools. Some of the best known of these techniques are: computer-assisted instruction, individually programmed instruction, the responsive environment or "talking typewriter", educational games, and that relatively old example of the new technology, educational television.

At the same time our society has become increasingly frustrated by the failure of the schools to teach or motivate large numbers of disadvantaged youngsters. Complicating this failure has been the fact that spending additional money for so-called compensatory education has not improved to any significant degree these educational outcomes. Indeed, it appears that where there has existed a basic failure among traditional educational approaches, the simple expedients of spending more money on reduced class size and additional remedial services are inadequate for resurrection. So, increasingly in the post-Sputnik era the bankruptcy of the schools has led to many demands and proposals for substantial changes in the instructional process.

Given these three coinciding developments, one might expect a significant interaction among them. That is, we might expect to find the new instructional technologies being evaluated for their relative efficiencies in producing educational outcomes; and the ones showing the greatest effectiveness relative to their costs would replace the allegedly less efficient traditional schooling processes. Paradoxically, this interaction has not taken place. The typical school continues to carry out its tasks in the same manner as it has always done. In fact, no reliable information on the relative costs and benefits of the new instructional technologies (or even

the old ones) has become available. Schools and school districts have no objective data with which they can make determinations based upon the relationships between costs and performances of alternative instructional strategies.

Given this dearth of data, the schools have been very slow to adopt new techniques, and this conservatism has strong justification. There simply is no available knowledge that schools can draw upon to determine whether the new instructional approaches will be more effective, once costs are taken into account, than are traditional instructional approaches.

The purpose of this paper is that of explaining this paradox by outlining the problems that arise in applying cost-effectiveness evaluations to instructional technologies. It will be shown that most of the requirements for sound cost-effectiveness analysis cannot be satisfied given our present knowledge of the educational process.

Requirements for Cost-Effectiveness Evaluation

Like other productive enterprises, schools can be said to have three general properties which taken together define a "production process." First, there are educational objectives which can be defined as the output of the process; second, there are students, teachers, administrators, buildings, and other materials and personnel which provide inputs into the educational process; and third, there exist techniques of combining the inputs in various combinations to produce the aforementioned educational objectives.

Before we can compare the benefits and costs of different educational alternatives, we must possess some reasonably reliable data on the relationships among inputs, processes, and educational outcomes. That is, the

task of cost-effectiveness analysis requires knowledge of the physical relations between inputs and outputs. Unfortunately, this information does not exist, even in a rudimentary form.

The inability to carry out cost-effectiveness analyses without these data can best be illustrated by presenting an example of how cost-benefit analysis has been applied to an area where it has yielded successful results, the evaluation of water-resource projects. _/

_/ Cost-benefit analysis has been used by the Corps of Army Engineers for more than 30 years. For a discussion of techniques used to evaluate water-resource projects, see John V. Krutilla and Otto Eckstein, Multiple Purpose River Development (Johns Hopkins Press, 1958).

Assume that we have a limited budget which must be allocated to that set of projects which will maximize benefits. Before the cost-effectiveness analyst sharpens his pencil he is given data on each of the proposed projects. Thus, he would be given information on such inputs as the amount of dredging required, the size of and specifications of the dam that will be built, and so on. He is also given a set of probable outcomes for each project; the degree of flood control, dimensions of the body of water that will be created by construction of the dam, hydroelectric output, and so on.

Given this information the cost-effectiveness analyst can estimate the value of social benefits that derive from reduced flood damage; new sources of water for irrigation, industrial, and drinking purposes; production of hydroelectric power, recreational potentialities and other outcomes. He can compare these with the initial and operating costs for

the project and any indirect costs. Having taken account of the benefits and costs of all projects, he can select that combination of projects which will maximize the returns to society for any given cost. What is important to note in this example is that the physical relationships between inputs and outcomes are given to the analysts by hydrologists, civil engineers, and other water resource experts. It is these basic data which are required before the economist, statistician, or operations researcher can estimate the resultant costs and benefits. Why is it that comparable information on the schools is not readily available?

Outputs

The prime difficulty in evaluating outcomes of schooling derives from the multi-dimensional aspect of education as well as severe inadequacies in our abilities to measure even single dimensions of output. Anyone who seeks to list educational objectives is faced with a bewildering array of goals that are claimed for the schools._/ While some of the goals are

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_/ See, for example, Benjamin S. Bloom (ed.), Taxonomy of Education Objectives Handbook I: The Cognitive Domain (New York: David McKay Company, 1956.

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straightforward, others appear to be vague, and almost all of them defy measurement. Certainly the schools are expected to provide students with adequate knowledge of and literacy in language skills, mathematics, sciences, and social studies. Then there are the more esoteric objectives of inculcating a set of common values, civic pride, patriotism, appreciation of

culture and aesthetics, and so on. It is often stressed that the schools are also responsible for preparing students to properly assume adult roles in our society. In actuality, the words describing these objectives tend to lull one into thinking that the objectives can be easily defined. Unfortunately, experience has shown that the specific goals which are masked by these descriptions are neither readily evident nor are they measurable.

Accordingly, the outputs which have usually been chosen for an analysis of school effectiveness have been standardized achievement scores, dropout rates, expected lifetime earnings, and rates of college attendance among high school graduates._/ To the degree that these measures mirror

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_/ For a discussion of outputs see Jesse Burkhead et. al., Input and Output in Large-City High Schools (Syracuse: Syracuse University Press, 1967), Chaps. I-II. For some original work which discusses the effect of compensatory education programs on the alleviation of poverty within a cost-benefit framework, see Thomas I. Ribich, Education and Poverty (Washington, D.C.: Brookings Institution, 1968). And for a cost-benefit analysis of dropout prevention see Burton Weisbrod, "Preventing High School Dropouts," in Measuring Benefits of Government Investments, Robert Dorfman (ed.) (Washington, D.C.: The Brookings Institution, 1965), pp. 117-167.

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to a great extent the ostensible successes or failures of individuals in middle class society, they are certainly important criteria. Nevertheless they may merely reflect that part of student behavior which is measurable in some gross sense. Unfortunately, like the visible portion of the iceberg, the greater part of educational output may be hidden from view.

Yet, one salient feature of educational output must be emphasized strongly. No matter which type of outcome one wishes to measure, the goals of the schooling process must be viewed as those of changing the potentialities, proficiences, and attitudes of the students who enter that process.

That is, schools are expected to change people in socially desirable ways (and one might also wish that the reverse were true). Students enter the schooling process as a relatively raw material, and the schools as well as concomitant family, community, and other influences transform these students into what might be characterized as "more-nearly finished" products. Thus the output of the school must be conceived of as the value-added to its student input -- the difference between the value of the student output and student input.

In this sense the absolute levels of high school dropouts, college attendance, or achievement scores should not be used as measures of school output. Rather, the effectiveness of a school along these dimensions must be gauged by its success in decreasing dropout rates, increasing educational motivation, and increasing achievement among a given set of students. In particular, students of lower socio-economic status generally enter the schools less well prepared and with less educational support from their families than their middle-class counterparts. Even if the same amount of change were to take place among both groups of students, the disadvantaged students would show lower proficiencies at the end of the educational process. Therefore, it is the "value-added in performance, attitudes, and other behavioral dimensions that must be related to schooling inputs. Unfortunately, many commentators appraise the performance of schools on the value of the student outputs alone, without taking account of differences in the proficiencies of incoming students.

Simply taking account of the social class of students in looking at differences in achievement levels -- as some researchers have done -- does not solve this problem._/ Indeed, outputs must be directly measured as

_/ See the discussion on this point in Samuel S. Bowles, "Towards an Educatinnal Production Function," A paper presented at the Conference on Research in Income and Wealth, University of Wisconsin (November 15, 1968), pp. 23-27.

changes or growth along the pre-specified cognitive and affective dimensions. One way of doing this given the ordinal nature of test and attitudinal instruments is to measure the relative differences on a normalized scale at two points in time. That is, a school might have students who score at the 38th percentile on a standardized test of reading comprehension at grade 4, and at the 51st percentile in reading comprehension at grade 6 (using national norms for similarly constituted student samples at each grade level). The relative position of other schools might deteriorate. This approach represents a crude approxmimation of relative value-added, though it tells us nothing about absolute gains and is subject to all kinds of testing aberrations._/

_/ Burkhead used a variant of this technique in the work previously cited. Unfortunately, problems with his data, statistical approach, and specification of inputs prevented him from deriving useful results. See Input and Output in Large-City High Schools, See pp. 53-56, 71-73, and 83-84. An example of the problems inherent in using test scores as measures of output is the fact that the test scores will improve simply by taking tests more frequently. That is, students an develop test-taking abilities that will improve scores. Holding other things constant, schools with extensive testing programs would show larger relative gains than those with more modest programs.

One value-added measure that seems useful is the increase in productivity and lifetime income attributable to additional years of schooling. Even after adjusting for differences in students' abilities and opportunities it appears that additional schooling yields substantially higher earnings to the average individual._/ Yet, we have no information which would

_/ See Gary S. Becker, Human Capital (New York, Columbia University Press, 1964).

relate changes in the quality of schooling and the implementation of particular instructional techniques to changes in productivity and lifetime earnings. One possible approach is that of relating instructional techniques to changes in standardized achievement scores and subsequently relating differences in standardized achievement scores to differences in earnings (after accounting for such intervening factors as the returns to higher levels of schooling.) _/ Much work needs to be done in the area of

_/ This technique might be used in a crude form with the recently available follow-up and earlier set of data collected by Project Talent.

specifying and measuring outputs.

Production of Schooling

Assume that we could measure educational output satisfactorily. The next goal would be to find out how these outputs are produced; satisfying this objective we could specify inputs; and finally we could assess costs and benefits. Unfortunately, even given a specified outcome, we do not know how it is produced. That is, the complexity of the world in which education takes place has thus far prevented us from inferring specific and reasonably predictable relations between educational strategies and educational results.

Indeed the basic lack of specific knowledge on how learning or attitude formation takes place represents the greatest obstacle to cost-effectiveness analysis. In the case of water resource projects we know that by building a dam, some fairly predictable outcomes will ensue. In the case of education we have the problem that even if we arbitrarily select and measure both outputs and inputs, there are enormous difficulties in ascertaining how changes in any specified set of inputs will change outputs. The interactions among inputs and outcomes are so complex, and psychological processes are so little understood, that even sophisticated statistical techniques, the best available data, and the most advanced computers have not been able to reveal answers in this area where we lack basic theory._/

_/ For an example of the controversy on the validity of evidence derived in one of the largest studies on the determinants of scholastic achievement see, James S. Coleman, Equality of Educational Opportunity, Chapter III; Samuel S. Bowles and Henry M. Levin, "The Determinants of Scholastic Achievement," The Journal of Human Resources (Winter 1968), pp. 3-24. See also the communication by Coleman in the Journal of Human Resources (Spring 1968), and those by Marshall Smith; Glen Cain and Harold Watts; and Bowles and Levin in the Journal of Human Resources (Summer 1968)

Thus, not knowing how schooling is produced we probably know even less about the specification and measurement of educational inputs than we know about outputs. It is true that we can measure per pupil expenditures, pupil-teacher ratios, physical facilities, and so on. Yet, if we have learned anything about the learning process it is that we must measure inputs in relation to their interactions with students. By this standard, it is the

quality of the prime inputs that we must be concerned with as much as their quantities.

In the present schooling process, teachers represent about 70 percent of the current budget, so we must be especially concerned with the teacher input. The standard measures of teacher input tell us little about the quality of interaction between student and teacher. The traditional measures have been class size, the teacher's degree level, and teaching experience. These measures have been used because of their visibility. Yet, little evidence is available that shows any relationship between such measures and school effectiveness.

Even fairly substantial reductions in average class size do not seem to have improved the quality of teacher-student interactions._/ Moreover,

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_/ For strong evidence on this point in the light of drastic reductions in class size and student/teacher ratios see David J. Fox, "Expansion of the More Effective School Program," Evaluation of New York City Title I Educational Projects 1966-67 (New York: Center for Urban Education, 1967), pp. 32-44.

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such factors as the degree level and experience of teachers vary so much in quality among teachers that they, too, have rarely shown any relation to school effectiveness.

Recent evidence suggests that those teacher traits which have not been readily visible such as attitudes and verbal facility show stronger associations with student achievement than do any of the former measures._/

_/ See for example the evidence in Henry M. Levin, Recruiting Teachers for Large-City Schools (Washington, The Brookings Institution, forthcoming.) See also, Samuel Bowles, op. cit.

Moreover, experimentation is just beginning to denote those particular teachers' attitudes, that seem to affect the performances of students._/

_/ See for example, Robert Rosenthal and Lenore Jacobson, Pygmalion in the Classroom (New York: Holt, Rinehart, and Winston, 1968). Also see Ned A. Flanders, Teacher Influence, Pupil Attitudes and Achievement, U. S. Department of HEW, Office of Education Cooperative Research Monograph No. 12 (Washington, D.C., U. S. Government Printing Office, 1965).

Yet, our state of knowledge is still too sparse to be able to accurately specify and measure those teacher attributes which are most highly related to educational outcomes.

Further, non-teacher inputs seem to be measured in very naive ways. For example, the presence of certain facilities or the age of a building is considered to be a reasonable measure of physical schooling facilities. This approach ignores the relevance of physical inputs by measuring them in such a way that student-facility interactions are ignored. For example, the presence of science laboratories tells us little about the quality or quantity of science instruction. Most high schools contain science laboratories as a standard part of their institutional design. Yet these laboratories vary in their equipment, their extent of use, and the degree to which they are integrated into the science program. In many schools science laboratories exist but are rarely used because teachers with science training are in short supply due to existing salary policies. _/ Yet a recent

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_/ See my Recruiting Teachers for Large-City Schools.

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survey by the U. S. Office of Education used the presence of science laboratories as one of the two facilities measures that might affect verbal

achievement. _/

_/ James S. Coleman et. al., Equality of Educational Opportunity, U. S. Department of Health, Education, and Welfare. (Washington, D.C.: 1966). On the basis of science laboratories and library books alone, the Report concluded that school facilities show little or no relation to achievement. See p. 316.

Likewise, the existence of educational television or some other form of instructional technology must be analyzed as an input in the way that it interacts with students and faculty. Simply specifying that some schools used closed-circuit television and others did not tell us little about the schooling process. That is, the existence of a physical facility tells us little about the extent or quality of its use.

In short, just as outputs are highly speculative and poorly measured, we have very little available information on inputs into the schooling process or the learning process. Attention has been devoted to measuring quantities of visible inputs with little attention devoted to their qualities; and emphasis has been focused on the presence of certain visible features of schools rather than asking the more basic question of what constitutes the schooling process.

But the job of the cost-effectiveness analyst is that of evaluating the costs and benefits of different strategies. Information on inputs, processes, and resultant outcomes are the necessary prerequisites with which he must work, and the delicate job of translating this morass of information into a set of alternatives that can be readily compared by the decision maker is his science. If his information requirements are not satisfied, he cannot satisfactorily execute his task.

Some Confusion

Yet, so-called cost-effectiveness analysis is taking place in education with far too much claimed for it at this stage. One such effort has stated that it can translate expenditures on Title I programs into all kinds of educational outcomes including increases in lifetime earnings. _/ While

_/ See Abt Associates, Inc., "Design for an Elementary and Secondary Education Cost-Effectiveness Model" Report on the Mathematical Design Phase, Contract OEC 1-6-001681-1681, (U. S. Office of Education: February, 1967).

no mechanism is shown for accomplishing this formidable task, the non-technical reader is seduced by flow diagrams, mock computer printouts, algebra, calculus, and a discussion of properties of statistical functions. Unfortunately, none of these solve the difficult problem for which the report claims it has the framework for solution.

Another report on cost-effectiveness analysis estimates actual benefit cost ratios without knowing the true costs of programs, what the programs consist of and their effects on student outcomes. That is, it never examines the ingredients of the programs; it merely assumes a causal link between changes in aid-to-the-disadvantaged and any improvement in their performance level over a period of time. _/

_/ See Robert Spiegelman, et. al., "A Benefit/Cost Model to Evaluate Educational Programs," Stanford Research Institute (January 1968).

Yet, I am optimistic enough to believe that many of these problems will be substantially overcome, and cost-effectiveness analysis will soon yield

benefits greater than its own costs. Recent evidence, for example, has suggested that recruiting and retaining teachers with higher verbal facility is five to ten times as effective per dollar of teacher expenditure in raising achievement scores of students as the strategy of obtaining and retaining teachers with more experience. _/

_/ See Henry M. Levin, "Cost-Effectiveness Analysis and Educational Policy -- Profusion, Confusion, Promise," A paper presented to the 34th National meeting of the Operations Research Society of America, Philadelphia (November 8, 1968).

But before meaningful progress can be made we must be honest about the current state of the art as applied to education. Anthony Oettinger has stated this point succinctly:

> "The systems analyst . . . owes it to the ideal of professional integrity to tell his client the truth as he sees it, not as the client would like to hear it. He may or may not have a useful prescription. Polio has been conquered, a mumps vaccine has just come out, but the common cold and cancer are still with us." _/

_/ "The Myths of Educational Technology," Saturday Review (May 18, 1968), p. 91.

The point is that we must recognize the formidable height of the barriers placed in the path of cost-effectiveness analyses in education rather than pretending that our hurdling ability is sufficient over any course. It is only by recognizing the magnitude of the hurdles that we will be able to surmount them rather than stumbling into them headlong.